

# Economic and Job Forecasts for the Sustainable Energy Industries in the USA

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**Abstract—** This paper presents a comprehensive definition and forecast of the sustainable energy industries in the USA to 2030. It develops a rigorous definition of the sustainable energy industries, estimates their current sizes and composition, including technology, sales, tax revenues generated, jobs, occupations, and skills, and forecasting their growth to 2030 under three scenarios for the U.S. and Ohio. It forecasts the growth of these industries under three scenarios: 1) a “business as usual” scenario that assumes no change in policy, 2) a Moderate Scenario that assumes that various moderate, incremental Federal and state sustainable energy initiatives are put in place over next two decades, and 3) an Advanced Scenario that “pushes the envelope” on the sustainable energy industries possible from current or impending technologies and includes what may realistically be feasible both economically and technologically in such a “crash” scenario. It finds that the sustainable energy industries create a variety of high-paying jobs, many of which take advantage of manufacturing skills currently going unused as manufacturing continues to undergo restructuring in the U.S., and that wages and salaries in many sectors of these industries are higher than U.S. average wages. An important implication of this study is that, while energy and the environment present many challenges, addressing these challenges also represents a potential opportunity. Existing sustainable energy industries will have to greatly expand, new industries will have to be developed, and rapidly growing sustainable energy industries can be a major part of a new American industrial revolution engendered by the need to address climate issues and related energy and environmental challenges.

**Index Terms—** Climate change, economic forecasts, energy efficiency, job forecasts, renewable energy, sustainable energy

## I. INTRODUCTION

There is widespread agreement in the U.S. that the sustainable energy industries -- renewable energy and energy efficiency (RE&EE) -- must play a significant role in the future energy mix. Nevertheless, despite this widespread and increasing interest, until recently a comprehensive study of these industries had never been conducted. Our study addresses this problem, and the major contributions of the research reported here include:

- Development of a rigorous definition of the sustainable energy industries
- Estimation of their current sizes and composition, including technology, sales, tax revenues generated, jobs, occupations, and skills

- Forecasting their growth to 2030 under three scenarios for the U.S. and Ohio

It is anticipated that these data will provide a foundation for subsequent analyses of the sustainable energy industries conducted by researchers.

Below we summarize the major findings of the research and indicate the implications for addressing pressing energy and environmental issues.

## II. THE U.S. SUSTAINABLE ENERGY INDUSTRIES IN 2006

We found that, in 2006, the U.S. sustainable energy industries generated \$970 billion in sales and created nearly 8.5 million jobs in the U.S. – including \$51 billion in sales and over 500,000 jobs in Ohio. These sales represent substantially more than the combined 2006 sales of the three largest U.S. corporations (Wal-Mart, ExxonMobil, and GM). These sustainable industries are growing faster than the U.S. average and contain some of the most rapidly growing industries in the world, such as wind, fuel cells, recycling, and biofuels. With appropriate federal and state government policies, these industries could by 2030 generate 40 million jobs per year in the U.S. – including nearly 2.3 million jobs in Ohio.

Tables 1 and 2 show the estimated 2006 sizes of the sustainable energy industries in the U.S. and in Ohio. In the U.S. for RE:

- Gross revenues totaled nearly \$40 billion and the number of jobs created by RE totaled 450,000
- Jobs created were disproportionately for scientific, technical, professional and skilled workers, and more than 90 percent of the jobs were in private industry
- Nearly 70 percent of the jobs were in the biomass sector – primarily ethanol and biomass power, and the second largest number of jobs was in the wind sector of the industry, followed by the hydroelectric and the geothermal sectors.

In the U.S. for EE:

- Gross revenues totaled \$933 billion and the total number of jobs created by EE exceeded 8 million.
- More than 90 percent of the jobs were in private industry and over 50 percent of the jobs were in the manufacturing sector.
- The second largest number of jobs was in recycling, followed by the construction industry.

## The Ohio Sustainable Energy Industries in 2006

In Ohio, for RE:

- Gross revenues totaled nearly \$800 million
- The number of jobs created totaled more than 6,600
- Jobs created were disproportionately for scientific, technical, professional and skilled workers, and more than 90 percent of the jobs were in private industry
- The largest number of jobs was in the wind sector, followed by the biomass and the geothermal sectors

In Ohio, for EE:

- Gross revenues totaled more than \$50 billion
- The number of jobs created totaled nearly 500,000
- More than 90 percent of the jobs were in private industry, and over 50 percent of the jobs were in the manufacturing sector
- The second largest number of jobs was in recycling, followed by durable manufacturing and vehicle manufacturing

We conducted a survey of existing sustainable energy companies in Ohio, examining a functional, technological, and geographic mix of companies. As illustrated in Table 3, our research revealed a wide range of firms, and they:

- Are located throughout the state, in major urban centers, suburbs, small towns, and rural areas.
- Range in size from small firms of several employees to large firms employing hundreds
- Are engaged a wide variety of activities, including manufacturing, engineering, R&D, analysis, installation, maintenance, etc.
- Require a wide variety of occupations, skills, education, training, and experience
- Include some of the most sophisticated, innovative, high-tech firms in the state

### III. SUSTAINABLE ENERGY INDUSTRY FORECASTS

Three scenarios to 2030 were forecast for the U.S. and Ohio: The Base Case, the Advanced Scenario, and the Moderate Scenario. The Base Case:

- Is essentially a “business as usual” scenario, assumes no change in policy, assumes no major sustainable energy initiatives over next 23 years, and assumes that the U.S. and Ohio RE&EE industries continue to develop according to the general trends and rates of growth experienced over past two decades
- Indicates that RE development is minimal, and was used as a comparison against the two alternative scenarios

The Moderate Scenario:

- Assumes that various moderate, incremental (above the base case) Federal and state sustainable energy initiatives are put in place over next two decades
- Is based on various “mid-range” estimates, incorporating modest initiatives

The Advanced Scenario:

- “Pushes the envelope” on the sustainable energy industries possible from current or impending technologies and includes what may realistically be feasible both economically and technologically in such a “crash” scenario. Assumes the sustainable energy industries are available to take the U.S. in a new direction, but that appropriate, aggressive public policies at the Federal and state levels are required and must be sustained over next two decades
- Represents a dramatic indication of what would be possible under an aggressive sustainable energy scenario

### IV. THE U.S. SUSTAINABLE ENERGY INDUSTRIES IN 2030

The scenario forecast results for the U.S. are summarized in Table 4 and Figures 1 and 2, and indicate that:

- In the base case: RE revenues increase 145 percent, from \$39 billion to \$95 billion; EE revenues increase 95 percent, from \$933 billion to \$1,818 billion
- In the base case: Jobs created by RE increase 190 percent, from 446,000 to 1.3 million; jobs created by EE increase 85 percent, from 8 million to 15 million
- In the advanced scenario, RE revenues increase 1,400 percent, from \$39 billion to \$597 billion; EE revenues increase 320 percent, from \$933 billion to \$3,933 billion
- In the advanced scenario: Jobs created by RE increase 1,700 percent, from 446,000 to 7.9 million (4.6 percent of total U.S. jobs); jobs created by EE increase 300 percent, from 8 million to 32 million (18.6 percent of total U.S. jobs)
- Thus, under all scenarios RE growth is much larger than EE growth; nevertheless, the economic and job impact of EE remains orders of magnitude larger than that of RE

### Sustainable Energy Industries and Related Occupations

Occupational data demonstrate that the sustainable energy industries create a variety of high-paying jobs, many of which take advantage of manufacturing skills currently going unused as manufacturing continues to undergo restructuring in the U.S. Regions with traditional manufacturing economies can recruit sustainable energy companies to take advantage of their highly skilled workforces, since, as illustrated in Table VIII-4, wind turbine manufacturing requires plant operators, machinists, mechanics, engineers, welders, etc.

As shown in Table XI-1, wages and salaries in many sectors of the RE&EE and related industries are higher than U.S. average wages. Although many high-tech industries almost exclusively require highly educated workers with masters or doctoral degrees, as noted, the sustainable energy industries require a wide variety of occupations. Nevertheless, many occupations in the sustainable energy industries include jobs which require associate’s degrees, long-term on-the-job training, or trade certifications, including engineers, chemists, electrical grid repairers, power plant operators and power dispatchers, chemical technicians, mechanical engineering technicians, and sustainable energy technicians, all of which pay higher than U.S. average wages.

With a wide variety of the required skills as well as ongoing research into RE&EE technologies, communities throughout the U.S can choose to build clusters around different segments of the sustainable energy industries. However, all state must recognize that they are in fierce competition as communities around the U.S. compete for new emerging energy industries with traditional university-centered research areas, including Palo Alto (Stanford University), Ann Arbor (University of Michigan), Trenton (Princeton University), the Research Triangle in North Carolina, and other university-industry complexes. In addition, communities must compete for sustainable energy jobs with traditional high-tech metropolitan areas like San Jose, Boston, and Washington D.C., along with metropolitan areas traditionally associated with manufacturing, like Dothan, Alabama. The wide variety of entrance points to the RE&EE industries makes this market easier to penetrate if states can market their strengths in high-tech, research, education, and construction and operation.

#### V. THE OHIO SUSTAINABLE ENERGY INDUSTRIES IN 2030

Analogous results for Ohio are summarized in Table 6 and Figures 3 and 4. This table and the figures illustrate that the Sustainable Energy industries offer significant development opportunities for Ohio:

- Under the advanced scenario, in 2030: RE could generate annually nearly \$18 billion in revenues and 175,000 jobs, and EE could generate annually over \$200 billion in revenues and over 2 million jobs
- Employment growth in RE&EE varies among sectors: Growing sectors include architecture and engineering, R&D, energy service companies (ESCO), environmental technologies, bio-fuels, power technologies, industrial processes, distributed generation, computer controls and systems, HVAC systems, and others
- RE&EE creates a variety of high-paying jobs, many of which take advantage of Ohio manufacturing skills
- Ohio, with its traditional manufacturing economy, can recruit RE&EE companies to take advantage of its skilled workforces for wind turbine manufacturing, biofuels production, etc.
- Wages in many RE&EE sectors are higher than the U.S. average, and RE&EE requires a wide mix of occupations
- RE&EE occupations include many jobs that require associate's degrees, on-the-job training, or trade certifications and which pay high wages
- Unlike some industries, sustainable energy industries offer a realistic target for job creation in Ohio, and state and local communities can build clusters around industry sectors
- Numerous entrance points make sustainable energy markets easier to penetrate if Ohio can utilize its strengths in workforce, technology, manufacturing, R&D, education, etc.

#### VI. OPPORTUNITIES AND CHALLENGES FOR OHIO – AND OTHER STATES

The economic and job development opportunities are important because Ohio needs a new source of jobs. For example:

- Over the past decade, Ohio total employment increased 2.7 percent.
- However, total U.S. employment increased 14 percent over same period – more than five times as fast
- Ohio's share of total U.S. jobs decreased from 4.4 percent to 4.0 percent
- Over this period, Ohio manufacturing jobs decreased 23 percent.
- Ohio's share of U.S. manufacturing jobs decreased from 6.0 percent to 5.6 percent
- In 1996, manufacturing jobs accounted for 19.4 percent of total Ohio jobs; currently they account for less than 14 percent

Sustainable energy industries can create new jobs in Ohio, and these industries generate skilled, well-paying jobs, many of which are not subject to foreign outsourcing. Sustainable energy industries can create jobs in two categories that Ohio is eager to attract and retain:

- College-educated professional workers, many with advanced degrees
- Highly skilled, technical workers, with advanced training and technical expertise, many of them in the manufacturing sector

Sustainable energy industries thus generate jobs that are disproportionately for highly skilled, well-paid, technical and professional workers, who provide the foundation for entrepreneurship and economic growth. These are the high-skilled, high-wage, technical and professional jobs that all states and regions seek to attract. However, it is important to note that Ohio is in competition with other states for these new energy economy jobs

Further, Ohio is not in forefront of some RE industries; for example:

- There are 31 photovoltaic manufacturing firms in the U.S., but only one in Ohio
- There are 25 solar thermal collector manufacturing firms in U.S., but none in Ohio
- Ohio has no major solar thermal manufacturing facility
- Ohio accounts for less than one percent of solar thermal collectors installed in U.S.
- It ranks only 22<sup>nd</sup> among states in terms of collectors installed
- It trailed far behind neighboring states; for example Michigan, Pennsylvania, and Illinois
- With no solar thermal manufacturing and few installations, Ohio has effectively ceded leadership in this segment of the sustainable energy industry

## VII. IMPLICATIONS

The research reported here is path-breaking in several respects:

- This is the first time that the sustainable energy industries have been rigorously specified and actual sales and employment numbers derived for a given year.
- Second, the industries have been disaggregated in detail by technology, sector, sub-industry, and jobs – total jobs and jobs by occupation and skill.
- Finally, these data have been forecast to 2030 on the basis of different scenarios relating to alternative government policies and incentives, including policies designed to address the climate challenge.

This work represents a major contribution in demonstrating how important sustainable energy industries are to the U.S. economy and labor market and provides the industry specifications and benchmarks which can be used in all related studies conducted subsequently. The research disaggregates the sustainable energy industries into their main components, such as wind, photovoltaics, biofuels, fuel cells, recycling, construction, electronics, vehicles, etc. Revenues, jobs, and occupational and skill requirements are estimated for each component and forecast to 2030. These forecasts can be related to different policies and strategies for addressing global warming and related energy and environmental priorities.

For Ohio, which has lost more than 230,000 manufacturing jobs over the past decade, the results are especially significant. Sustainable energy industries are already creating nearly twice as many jobs – 500,000 – as were lost in the manufacturing sector. More important, by 2030, if the state implements appropriate policies and incentives, these industries could create nearly ten times as many jobs in Ohio – 2.3 million -- as were lost in manufacturing over the past decade. The potential implications for other states are obvious.

However, the research also contains a cautionary note for Ohio – and for other states. Ohio is not in the forefront of sustainable energy technology or development and is far behind other states. As noted, Ohio has only one photovoltaic manufacturing firm and no solar thermal collector manufacturing firm. Absent changes in state government policies, Ohio will cede leadership in rapidly growing sustainable energy industries to other states – who are aggressively pursuing them.

An important implication of this study is that, while energy and the environment present many challenges, addressing these challenges also represents a potential opportunity. Existing sustainable energy industries will have to greatly expand, new RE&EE industries will have to be developed, and rapidly growing sustainable energy industries can be a major part of a new American industrial revolution engendered by the need to address climate issues and related energy and environmental challenges.

**Table 1**  
**Summary of the U.S. Sustainable Energy Industries in 2006**

Industry	Revenues (billions)	Direct Jobs (thousands)	Total (direct plus indirect) Jobs Created (thousands)
<b>Renewable Energy</b>	\$39.2	196	452
<b>Energy Efficiency</b>	932.6	3,498	8,046
<b>TOTAL</b>	\$971.8	3,694	8,498

Source: Management Information Services, Inc. and American Solar Energy Society.

**Table 2**  
**The Ohio Renewable Energy and Energy Efficiency Industries, 2006**

Industry	Revenues (millions)	Direct Jobs	Total (direct plus indirect) Jobs Created
<b>Renewable Energy</b>	\$785	2,880	6,615
<b>Energy Efficiency</b>	50,120	205,780	496,535
<b>TOTAL</b>	\$50,905	208,660	503,150

Source: Management Information Services, Inc. and American Solar Energy Society.

**Table 3**  
**Sustainable Energy Firms in Ohio**  
(Examples of Selected Firms)

Company	Sector	Location	Company	Sector	Location
Advanced Hydro Solutions	RE	Fairlawn	North Coast Wind & Power	RE	Port Clinton
American Ag Fuels	RE	Defiance	Novar Controls Corp.	EE	Cleveland
AMTEK Solid State Controls	EE	Columbus	O'Brock Windmill Distributors	RE	North Benton
CybetUtility	RE	Cleveland	Ohio Windmill Mfg. Co.	RE	Berlin Center
Dovetail Solar & Wind	RE	Glouster	Owens Corning	EE	Toledo
Energy Technologies, Inc.	EE	Mansfield	Renewable Lubricants, Inc.	RE	Hartville



EXTOL of Ohio	EE	Norwalk	Repower Solutions	EE	Cleveland
Eye Lighting International	EE	Mentor	Schward Electrical	RE	Dayton
Energy Technologies, Inc.	EE	Mansfield	SCI Engineered Materials	RE	Columbus
Essential Research, Inc.	EE& RE	Cleveland	Solar Creations	RE	Perrysville
First Solar	RE	Perrysburg	Special Materials Research	EE	Strongsville
Forry, Inc.	EE	Chagrin Falls	SSOE Systems, Inc.	EE	Toledo
Gardiner Trane	EE	Solon	Staco Energy Products	EE	Dayton
James Leffel & Company	RE	Springfield	SunLight Energy Systems	RE	North Lawrence
Jatro Diesel	RE	Mason	Sunpower, Inc.	RE & E	Athens
Joe Mescan Windmill	RE	Columbia Station	Technology Bus. Development	RE	North Ridgeville
Liquid Resources of Ohio	RE	Medina	Teron Lighting, Inc.	EE	Fairfield
M&B's Battery Company	RE& EE	Harrison	The Enterprise Corp.	EE	Twinsburg
Malcolm Pirnie	EE	Akron	Third Sun Solar & Wind Power	RE	Athens
Michael Byrne Mfg. Co.	EE	Mansfield	Universal Electric Power	RE	Akron
Mariner Energy Systems	EE	Brunswick	Vanner, Inc.	EE	Hilliard
Midwest Mechanical Power	RE& EE	Plain City	Venture Lighting	EE	Solon
National Electric Coil	EE	Columbus			

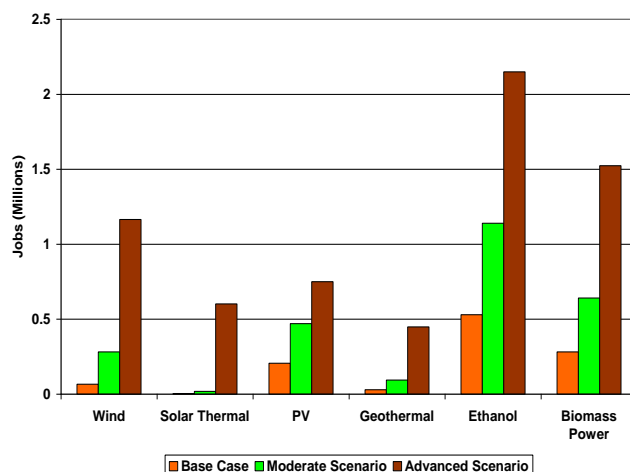
Source: Management Information Services, Inc. and Green Energy Ohio, 2008.

**Table 4**  
**Summary Of The U.S. Sustainable Energy Industries in 2030**

	Revenues (Billions of 2006 Dollars)			Total Jobs Created (Direct Plus Indirect – Thousands)		
	Base Case	Moderate Scenario	Aggressive Scenario	Base Case	Moderate Scenario	Aggressive Scenario
RE	\$95	\$227	\$597	1,305	3,138	7,918
EE	1,818	2,152	3,933	14,953	17,825	32,185
Total	\$1,913	\$2,379	\$4,530	16,258	20,963	40,103

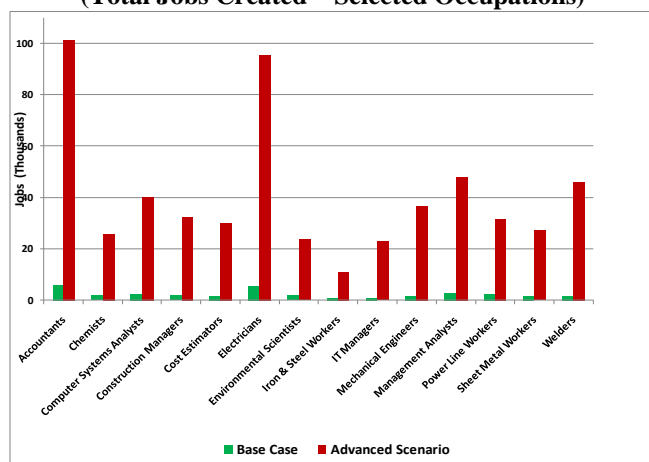
Source: Management Information Services, Inc. and American Solar Energy Society.

**Figure 1**  
**U.S. Jobs Created By Renewable Energy In 2030**  
**(Total Jobs Created – Selected Technologies)**



Source: Management Information Services, Inc. and American Solar Energy Society.

**Figure 2**  
**U.S. Jobs Created By Renewable Energy In 2030**  
**(Total Jobs Created – Selected Occupations)**



Source: Management Information Services, Inc. and American Solar Energy Society.

**Table 5**  
**Sustainable Energy Industries and Related Occupations:**  
**Wages, Educational Requirements, and Growth**  
**Forecasts**  
**(Selected Occupations)**

Occupation	10 year % Growth Forecast	Median Salary	% With Bachelor's Degree	Education
Materials Scientists	8	75,800	94	Bachelor's
Physicists	7	93,300	92	Doctoral
Microbiologists	17	64,600	96	Doctoral
Biological Technicians	17	37,200	60	Associate
Conservation Scientists	6	4,800	88	Bachelor's
Chemists	7	4,800	94	Bachelor's
Chemical Technicians	4	0,900	27	Associate
Geoscientists	6	4,700	94	Doctoral
Natural Science Managers	14	101,000	90	Bachelor's

## Economic and Job Forecasts for the Sustainable Energy Industries in the USA

Environmental Eng. Technicians	24	42,800	18	Associate
Soil and Plant Scientists	20	59,100	64	Bachelor's
Mechanical Eng. Technicians	12	47,400	18	Associate
Environmental Sci. Technicians	16	39,100	47	Associate
Biomedical Engineers	31	76,900	60	Bachelor's
Chemical Engineers	11	80,800	92	Bachelor's
Mechanical Engineers	10	78,600	88	Bachelor's
Electrical Engineers	12	77,700	83	Bachelor's
Environmental Engineers	14	76,000	82	Bachelor's
Computer Scientists	26	95,900	67	Doctoral
Life & Physical Sci. Technicians	20	46,100	50	Associate
Utility Plant Operatives	4	54,100	10	OJT
HVAC Technicians	12	38,300	14	OJT
Energy Audit Specialists	18	40,300	18	OJT
Forest & Conservation Workers	6	27,500	8	OJT
Refuse & Recycling Workers	5	26,400	2	OJT
Insulation Workers	6	\$30,800	2	OJT

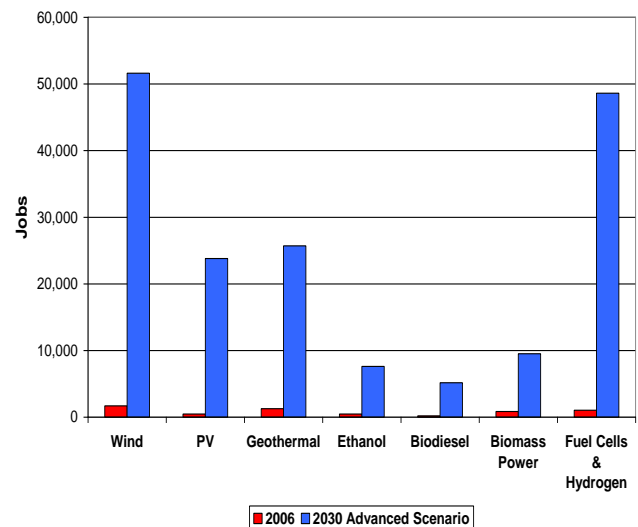
Source: Management Information Services, Inc. and U.S. Bureau of Labor Statistics.

**Table 6**  
**Summary of the Ohio Sustainable Energy Industries in 2030**

	Revenues (Billions of 2006 Dollars)			Total Jobs Created (Direct Plus Indirect – Thousands)		
	Base Case	Moderate Scenario	Aggressive Scenario	Base Case	Moderate Scenario	Aggressive Scenario
<b>RE</b>	\$2.0	\$5.7	\$17.7	21	56	174
<b>EE</b>	96.7	114.7	202.6	964	1,150	2,096
<b>Total</b>	\$98.7	\$120.4	\$220.3	985	1,206	2,270

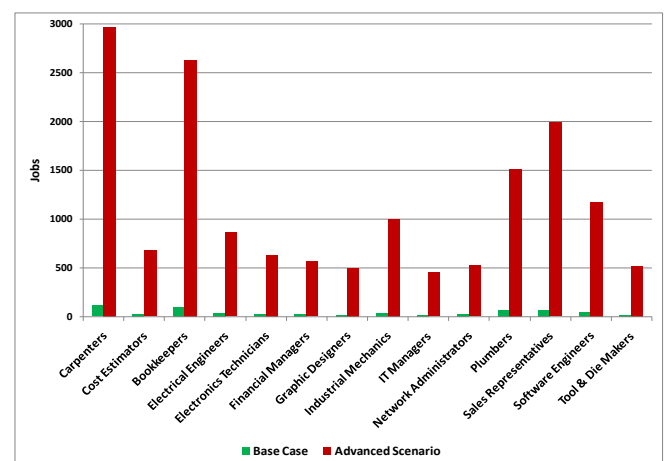
Source: Management Information Services, Inc. and American Solar Energy Society.

**Figure 3**  
**Ohio Job Growth 2006-2030 in Selected Renewable Energy Technologies**



Source: Management Information Services, Inc. and American Solar Energy Society.

**Figure 4**  
**Ohio Jobs Created By RE In 2030  
(Total Jobs Created -- Selected Occupations)**



Source: Management Information Services, Inc. and American Solar Energy Society